We claim:

1. An integrated optical device comprising:

an optical substrate, wherein an incident light signal is propagating within the substrate in a primary direction of propagation reflecting off a top surface of the substrate under total internal reflection; and

a diffractive optical element having a plurality of spaced-apart members formed of an optically transparent material and disposed above the top surface of the substrate such that the incident light signal is reflected within the substrate along a desired direction of propagation.

2. The integrated optical device of claim 1, wherein the substrate is formed of quartz.

3. The integrated optical device of claim 1, wherein the substrate is formed of sapphire.

4. The integrated optical device of claim 1, wherein the members are a plurality of strips that are substantially parallel.

5. The integrated optical device of claim 4, wherein the plurality of strips each have a substantially identical strip width.

6. The integrated optical device of claim 4, wherein the plurality of strips are each spaced apart a substantially equal spacing distance.

7. The integrated optical device of claim 4, wherein the plurality of strips each have a substantially identical strip width, the plurality of strips are each spaced apart a substantially equal spacing distance, and the spacing distance is substantially identical to the strip width.

8. The integrated optical device of claim 7, wherein the sum of the distance and width is between .5λ and 4λ, where λ is the wavelength of the light signal in the substrate.

9. The integrated optical device of claim 1, wherein the thickness of the members is adjusted to maximize the intensity of the reflected light signal

10. The integrated optical device of claim 1, wherein the members are formed of a material selected from the grouping consisting of amorphous silicon, crystalline silicon, and poly-silicon.

11. The integrated optical device of claim 1, wherein the members are formed of a material selected from the grouping consisting of alumina, sapphire, silicon nitride, and an alloy of poly-silicon and poly-germanium.

12. The integrated optical device of claim 1, wherein the members are disposed in direct contact with the top surface of the substrate.

13. The integrated optical device of claim 1, wherein the members are disposed in evanescent field coupling contact with the top surface of the substrate.

14. The integrated optical device of claim 1, wherein the diffractive optical element produces a first order diffracted mode that travels within the substrate in the desired direction of propagation at an angle to the primary direction of propagation.

15. The integrated optical device of claim 14, wherein the first order diffracted mode travels within the substrate under total internal reflection.

16. The integrated optical device of claim 1, wherein the incident light signal is a diverging beam and further comprising a collimating element adapted to receive the incident light signal, the collimating element being positioned so that the incident light signal from the collimating element is collimated in the substrate and traveling in the substrate under total internal reflection.

17. The integrated optical device of claim 16, wherein the collimating element comprises a holographic element mounted on the top surface of the substrate.

18. The integrated optical device of claim 1, wherein the light beam is coupled into the substrate through a GRIN lens.

19. The integrated optical device of claim 1, wherein the members are substantially parallel linear elements.

20. The integrated optical device of claim 1, wherein the members are formed on the top surface of the substrate by depositing a silicon material in a patterned form.

21. The integrated optical device of claim 1, wherein the members and the substrate are formed of the same material.

22. The integrated optical device of claim 21, wherein the material is sapphire.

23. The integrated optical device of claim 1, where the members have a higher index of refraction than that of the substrate.

24. The integrated optical device of claim 1, where the diffractive optical element operates by means of total internal reflection.

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25. The integrated optical device of claim 1, comprising a plurality of incident light signals each having a different wavelength and wherein the diffractive optical element reflects each channel into a different first order diffracted mode such that each reflected light signal travels within the substrate in one of plurality of secondary directions of propagation each at an angle to the primary direction of propagation and such that each reflected channel travels within the substrate under total internal reflection.

26. The integrated optical device of claim 1, wherein the members each have a width selected to maximize the intensity of the reflected light signal.

27. The integrated optical device of claim 1, wherein the members are formed of a plurality of strips, each strip having a width and an associated spacing, wherein the widths and the spacings vary among the strips.

28. The integrated optical device of claim 27, wherein the widths and the spacings vary in a continuous manner.

29. A diffraction grating for use with an optically transparent substrate, the diffraction grating comprising:

a plurality of members formed of an optically transparent material disposed above a top surface of the substrate, the members being spaced apart a spacing distance and having member widths, whereby the sum, a, of the spacing distance and the member width is chosen such that a light signal traveling within the substrate under total internal reflection off the top surface in an incident direction of propagation and incident upon the diffraction grating is reflected into a first diffracted order propagating within the substrate in a reflected direction of propagation defining an angle, θ_p, with respect to the incident direction of propagation and propagating within the substrate under total internal reflection.

30. The diffraction grating of claim 29, wherein the sum, a, is between $.5\lambda$ and 4λ, where λ is the wavelength of the light signal within the substrate.

31. The diffraction grating of claim 30, wherein λ is between .25 μm microns and 10 μm microns.

32. The diffraction grating of claim 29, wherein the light signal is incident upon the diffraction grating at an angle, θ, above a critical angle, θ being measured from a normal to the top surface of the substrate extending into the substrate, and wherein the sum a is chosen such that θ_p is greater than 90° and less than 180°.

33. The diffraction grating of claim 29, wherein the spacing distance is substantially identical to the member width.

34. The diffraction grating of claim 29, wherein the members are formed of a material selected from the grouping consisting of amorphous silicon, crystalline silicon, and poly-silicon and wherein the substrate is formed of sapphire.

35. The diffraction grating of claim 29, wherein the members have an index of refraction higher than the index of refraction of the substrate.

36. A method of routing an incident light signal comprising the steps of:

transmitting the incident light signal in an optical substrate under total internal reflection off of a top surface of the substrate; and

disposing a plurality of spaced-apart strips above the top surface of the substrate for receiving a portion of the incident light signal such that the plurality of strips form a diffraction grating that reflects the incident light into a first diffracted order propagating within the substrate in a reflected direction of propagation defining an angle with respect to an incident direction of propagation and propagating within the substrate under total internal reflection.

37. The method of claim 36, wherein the step of disposing a plurality of spaced-apart strips further comprises the steps of:

depositing a thin film of optical material on the top surface of the substrate;

applying a masking over the thin film;

exposing the thin film and the mask to a photolithographic exposure process to form a pattern within the thin film, the pattern corresponding to the strips; and

selectively etching portions of the thin film to form to the strips.

38. The method of claim 36, wherein the optical material is a poly-silicon material.

39. The method of claim 36, wherein the step of disposing the plurality of strips above the top surface forms the strips in direct contact with the top surface.

40. The method of claim 36, wherein the step of disposing a plurality of spaced-apart strips further comprises the steps of:

growing a thin film of crystalline silicon on the top surface of the substrate;

applying a masking over the thin film;

exposing the thin film and the mask to a photolithographic exposure process to form a pattern within the thin film, the pattern corresponding to the strips; and

selectively etching portions of the thin film to form the strips.

41. The method of claim 40, wherein the step of disposing the plurality of strips above the top surface forms the strips in direct contact with the top surface.

42. The method of claim 36, wherein the step of disposing a plurality of spaced-apart strips further comprises the steps of:

depositing a sacrificial layer on the top surface of the substrate;

depositing a thin film of an optical material over the sacrificial layer;

applying a masking over the thin film;

exposing the thin film and the mask to a photolithographic exposure process to form a pattern within the thin film, the pattern corresponding to the strips;

selectively etching portions of the thin film to form the strips; and

removing the sacrificial layer so that the strips are formed above the top surface of the substrate within an evanescent field coupling region extending above the top surface.

43. An integrated optical device comprising:

a substrate formed of an optically transparent material and having a light signal traveling within the substrate under total internal reflection;

a first diffractive optical element formed of a first plurality of spaced-apart members disposed above a top surface of the substrate so as to reflect the light signal within the substrate in a desired direction of propagation;

a second diffractive optical element formed of a second plurality of spaced-apart members and disposed above the top surface of the substrate to receive the reflected light signal from the first diffractive optical element and disposed to output the reflected light signal for propagation within the substrate.

44. The integrated optical device of claim 43, wherein the first diffractive optical element is a collimating element.

45. The integrated optical device of claim 43, wherein the desired direction of propagation is parallel to an incident direction of propagation of the light signal.

46. The integrated optical device of claim 43, wherein the output light signal from the second diffractive optical element propagates within the substrate along a first order diffracted mode having an angle to the desired direction of propagation, the output light signal also propagating within the substrate under total internal reflection.